Assessment of travel behaviour related to new mobility services

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New mobility services: E-micromobility

- E-micromobility = small electrically powered vehicles (e.g., e-scooters and e-bikes)

- E-micromobility → prospective alternative ?

i. Space-efficient
ii. Convenient
iii. Environmentally friendly
iv. Suitable for short trips

- Potential → complements public transportation and reduce car usage

i. Flexible = fills gap individual and public transport
ii. Expand an extended feeder service

- E-micromobility in a competetive situation

Explore e-micromobility travel behaviour

Methodology

Quantitative Survey

Purpose: evaluate user needs and requirements regarding e-micromobility

SP Experiment

Purpose: reveal individual´s utility for e-micromobility when compared with other transport modes.

- Create hypothetical choices in a questionnaire format
  - Hypothetical trip
  - Define alternatives and attributes (with their respective levels)
  - Reduce choice situations (fractional factorial)

Copenhagen

Munich

Barcelona

Tel Aviv

Stockholm

- Tools:

R — Creates questionnaires

LimeSurvey — Carry out survey and data results

BIOGEME — Model analysis

Explore e-micromobility travel behaviour

Methodology —— —— —— Part 2

SP Experiment

Labeled Design experiment → $L^{MA} = 3^{4*2} = 6561$ (possible choice situations) →

- Trip distance: **4km** (avoid natural exclusion of alternatives)
- Transport modes (4): **Car, PT, <u>E-micromobility</u>, Bike-sharing**
- Attribute types (2): **Cost and Time**
- Attribute levels (3)
  standard level of attributes
  over / below levels **(+/- 20%)**

Block partialisation using support.Ces and survival packages
9 designed blocks each with 9 questions

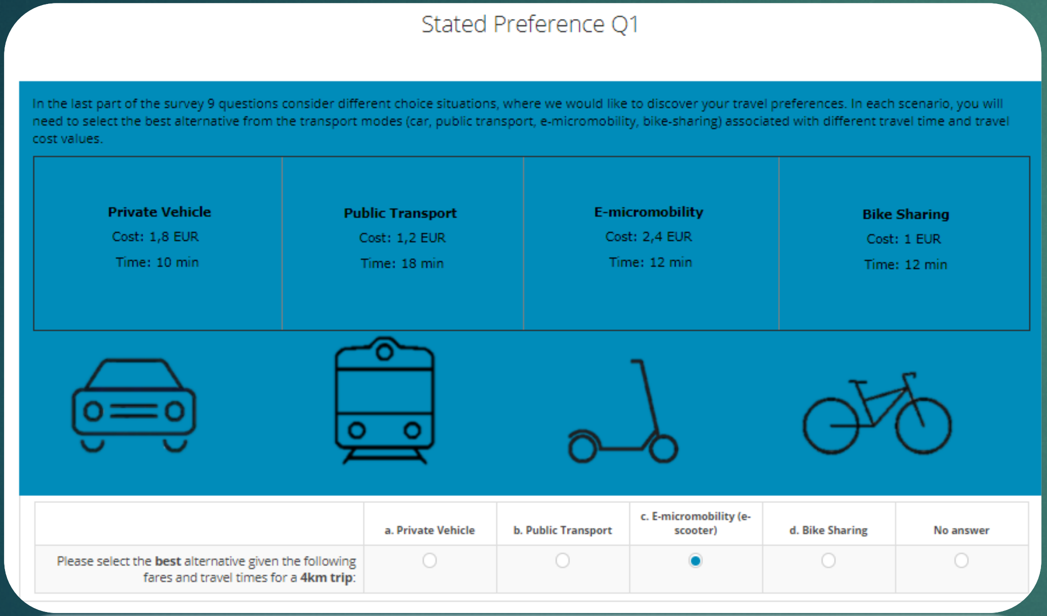
Respondents were assigned a number (1-9)
Assigned number = question to be answered from all 9 blocks

Answer Survey!

Explore e-micromobility travel behaviour

Methodology

SP Experiment



		Cost Attribute			Time Attribute		
User Cases	Alternatives	Below (-20%)	Standard	Over (+20%)	Below (-20%)	Standard	Over (+20%)
Copenhagen (DKK)	Car	18	22.5	27	10	12	15
	Public transport	12	15	18	18	20	24
	E-micromobility	24	30	36	12	15	18
	Bike-sharing	9	12	15	12	15	18
Munich (EUR)	Car	1.2	1.5	1.8	10	12	15
	Public transport	0.8	1	1.2	18	20	24
	E-micromobility	1.6	2	2.4	12	15	18
	Bike-sharing	0.6	0.8	1	12	15	18
Barcelona (EUR)	Car	1.2	1.5	1.8	10	12	15
	Public transport	0.8	1	1.2	18	20	24
	E-micromobility	1.6	2	2.4	12	15	18
	Bike-sharing	0.6	0.8	1	12	15	18
Tel Aviv (ILS)	Car	4.62	5.775	6.93	10	12	15
	Public transport	3.08	3.85	4.62	18	20	24
	E-micromobility	6.16	7.7	9.24	12	15	18
	Bike-sharing	2.31	3.08	3.85	12	15	18
Stockholm (SEK)	Car	28	35	42	10	12	15
	Public transport	24	30	36	18	20	24
	E-micromobility	24	30	36	12	15	18
	Bike-sharing	6	8	10	12	15	18

Explore e-micromobility travel behaviour

Methodology

SP Experiment

Multinomial Logit Model MNL

- Logit addressing probability condition => $P_i = \frac{e^{V_i}}{\sum_{j=1}^{J} e^{V_j}}$

Systematic function of alterantive i

Sum of all alternative´s systematic functions

- Systematic function => $V_{i,t} = ASC_i + \gamma_{i,k} S_{k,t} + \sum_m \beta_{i,m} X_{i,m}$

*** Weighted sum of attribute levels Xm of i*

****** utility associated with the respondent´s characteristics Sk*

- $V_{emic} = ASC_{emic} + \gamma_{emic,income} * inc + \beta_{fare} X_{emic,fare} + \beta_{time} X_{emic,time}$

respondent´s estimated average preference to alterantive, i

appended coefficients that defines direction (+ or -) and importance of (magnitude) of the attributes and respondent´s characteristics.

Explore e-micromobility travel behaviour

Methodology

SP Experiment

Model Results using Biogeme

INCOME_GROUP	FARE_CAR	FARE_PT	FARE_EMIC	FARE_BIKE	TIME_CAR	TIME_PT	TIME_EMIC	TIME_BIKE	chosen
7	22.5	15	30	12	15	24	18	18	4
4	22.5	15	30	12	15	24	18	18	3
6	22.5	15	30	12	15	24	18	18	2
3	22.5	15	30	12	15	24	18	18	3
4	22.5	15	30	12	15	24	18	18	2
6	22.5	15	30	12	15	24	18	18	2
6	22.5	15	30	12	15	24	18	18	4
9	22.5	15	30	12	15	24	18	18	4
6	22.5	15	30	12	15	24	18	18	4
7	22.5	15	24	9	12	18	15	18	4
4	22.5	15	24	9	12	18	15	18	3
6	22.5	15	24	9	12	18	15	18	2
3	22.5	15	24	9	12	18	15	18	3
4	22.5	15	24	9	12	18	15	18	2
6	22.5	15	24	9	12	18	15	18	2
6	22.5	15	24	9	12	18	15	18	4
9	22.5	15	24	9	12	18	15	18	4
6	22.5	15	24	9	12	18	15	18	4
7	27	12	24	15	15	18	18	15	2
4	27	12	24	15	15	18	18	15	3
6	27	12	24	15	15	18	18	15	2
3	27	12	24	15	15	18	18	15	3
4	27	12	24	15	15	18	18	15	2
6	27	12	24	15	15	18	18	15	2
6	27	12	24	15	15	18	18	15	4
9	27	12	24	15	15	18	18	15	4
6	27	12	24	15	15	18	18	15	2
7	22.5	12	24	15	12	24	15	15	0
4	22.5	12	24	15	12	24	15	15	0
6	22.5	12	24	15	12	24	15	15	0
3	22.5	12	24	15	12	24	15	15	0
4	22.5	12	24	15	12	24	15	15	2
6	22.5	12	24	15	12	24	15	15	0
6	22.5	12	24	15	12	24	15	15	4
9	22.5	12	24	15	12	24	15	15	4
6	22.5	12	24	15	12	24	15	15	4
7	22.5	18	36	9	15	18	18	15	4
4	22.5	18	36	9	15	18	18	15	3
6	22.5	18	36	9	15	18	18	15	2
3	22.5	18	36	9	15	18	18	15	2
4	22.5	18	36	9	15	18	18	15	2
6	22.5	18	36	9	15	18	18	15	2
6	22.5	18	36	9	15	18	18	15	4
9	22.5	18	36	9	15	18	18	15	4
6	22.5	18	36	9	15	18	18	15	4
7	18	12	30	12	15	20	18	12	4
4	18	12	30	12	15	20	18	12	3
6	18	12	30	12	15	20	18	12	2
3	18	12	30	12	15	20	18	12	2
4	18	12	30	12	15	20	18	12	2

(1) “clean” data from responses

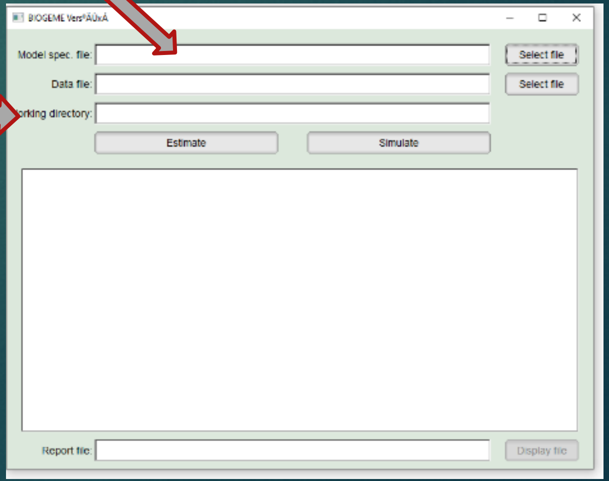
```
[ModelDescription]
"Multinomial Logit choice Model Copenhagen Version"


[Choice]
chosen


[Beta]
// Name          Value     LowerBound    UpperBound    status (0=variable, 1=fixed)
ASC_CAR          0         -10000        10000         1
GAMMA_INCOME_CAR  0        -10000        10000         1
ASC_PT           0         -10000        10000         0
GAMMA_INCOME_PT 0          -10000        10000         0
ASC_EMIC         0         -10000        10000         0
GAMMA_INCOME_EMIC 0        -10000        10000         0
ASC_BIKE         0         -10000        10000         0
GAMMA_INCOME_BIKE 0        -10000        10000         0
BETA_FARE        0         -10000        10000         0
BETA_TIME        0         -10000        10000         0


[Utilities]
// Id   Name              Avail linear in paramter expression (beta1*x1 + beta2*x2 + ... )
   1    CAR                one     ASC_CAR  * one + GAMMA_INCOME_CAR  * INCOME_GROUP + BETA_FARE * FARE_CAR  + BETA_TIME * TIME_CAR
   2    PT                 one     ASC_PT   * one + GAMMA_INCOME_PT   * INCOME_GROUP + BETA_FARE * FARE_PT   + BETA_TIME * TIME_PT
   3    EMIC               one     ASC_EMIC * one + GAMMA_INCOME_EMIC * INCOME_GROUP + BETA_FARE * FARE_EMIC + BETA_TIME * TIME_EMIC
   4    BIKE               one     ASC_BIKE * one + GAMMA_INCOME_BIKE * INCOME_GROUP + BETA_FARE * FARE_BIKE + BETA_TIME * TIME_BIKE
```

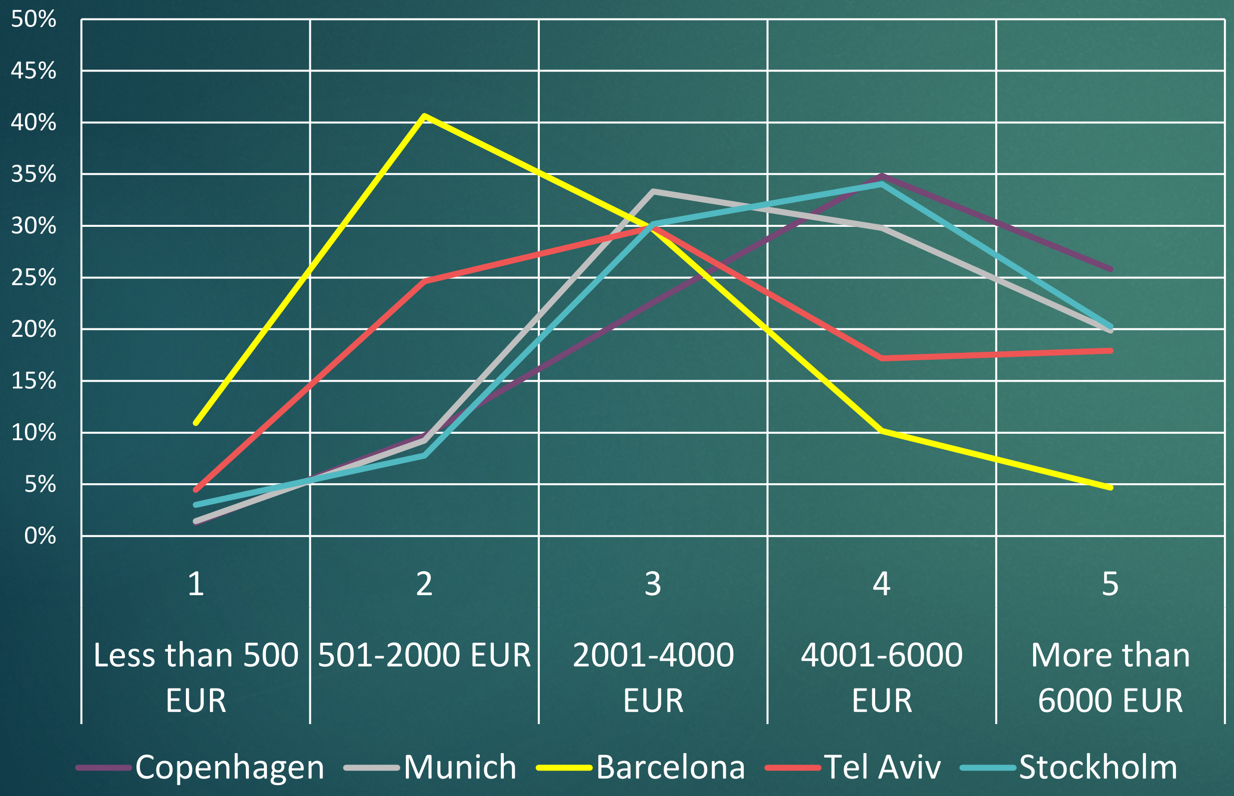
(2) Model specification



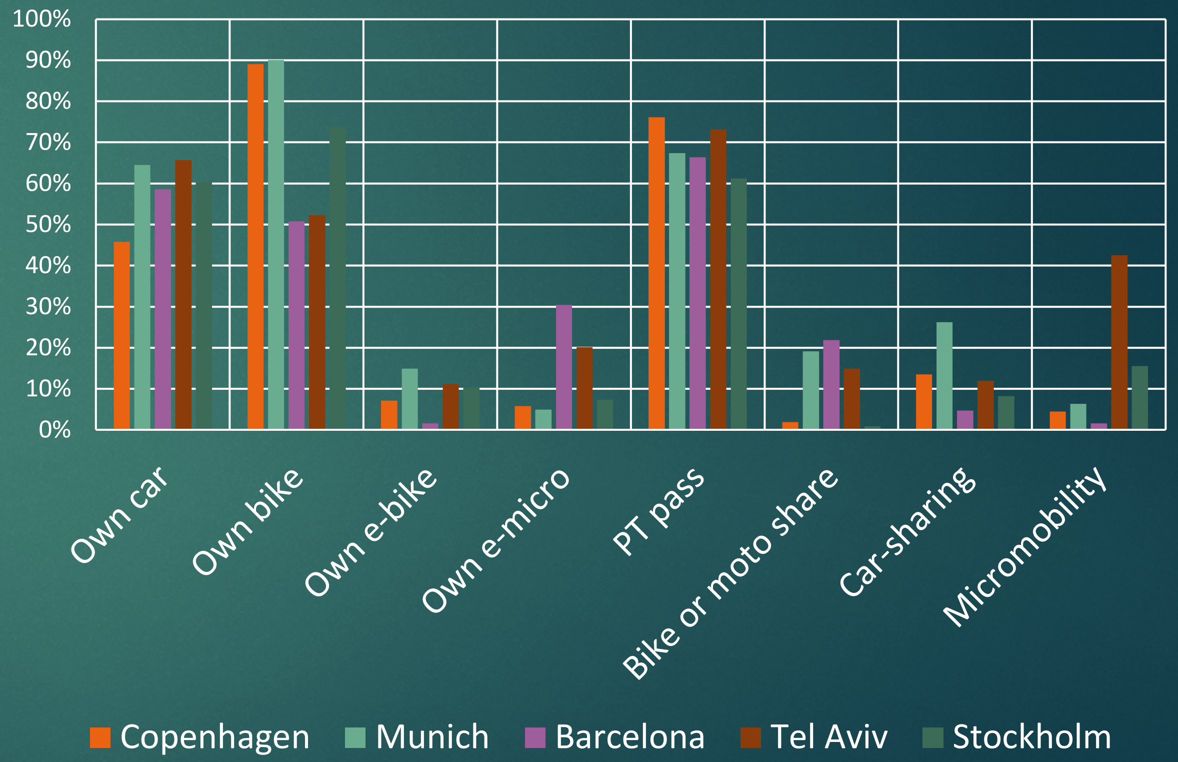
Explore e-micromobility travel behaviour

Results

Quantitative survey approach



Income data from respondents

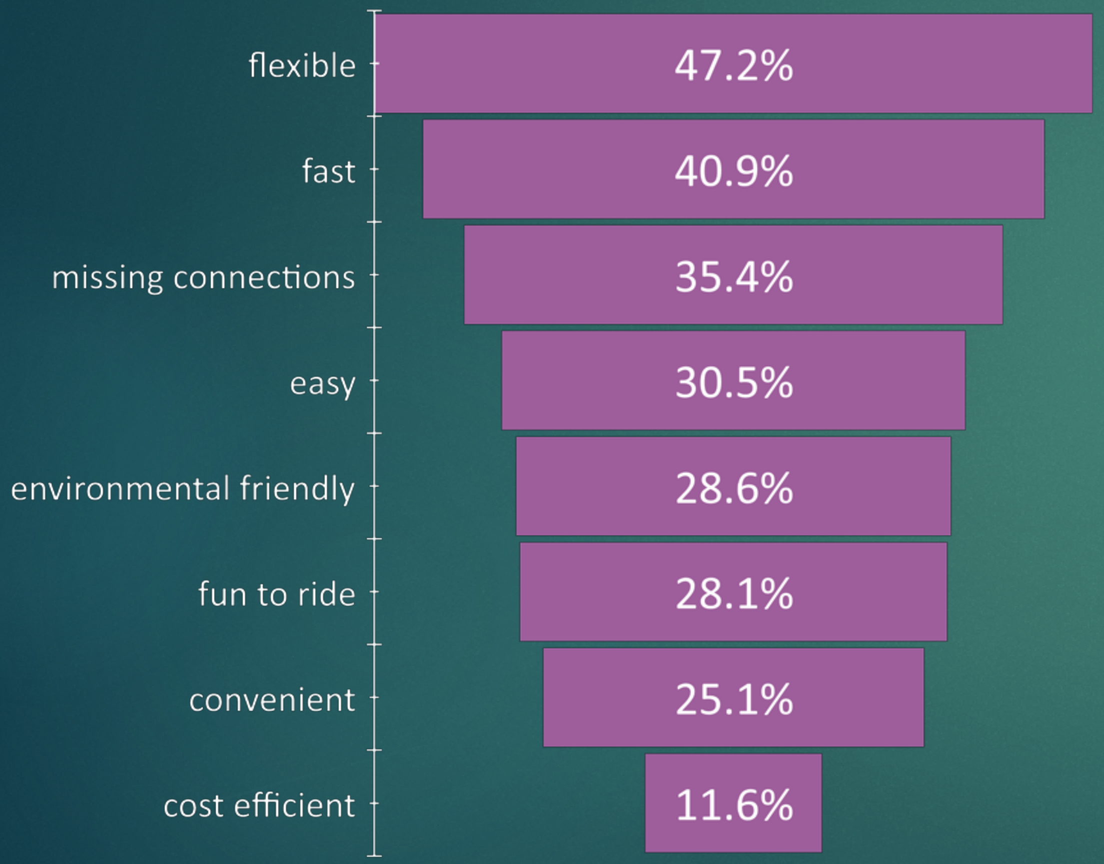


Transport opportunites

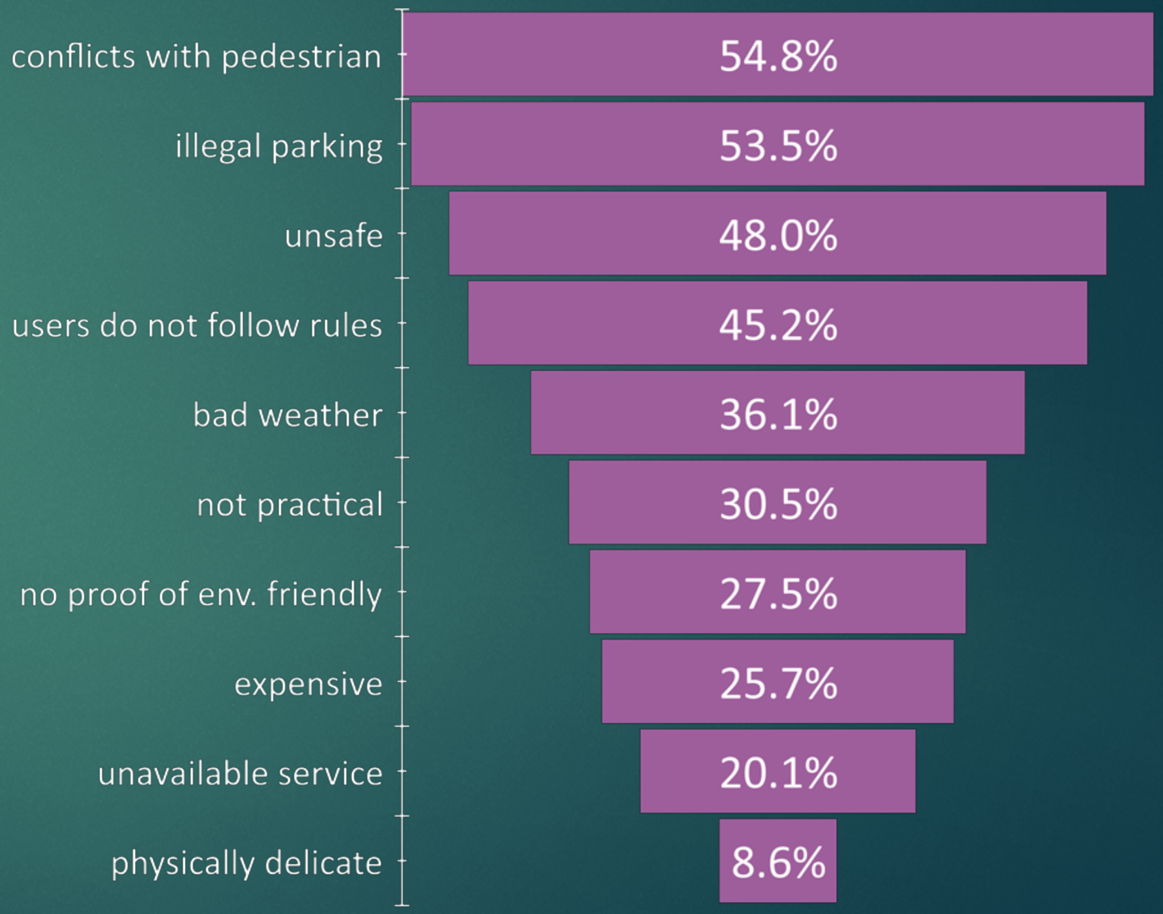
Explore e-micromobility travel behaviour

Results

Quantitative survey approach



Benefits

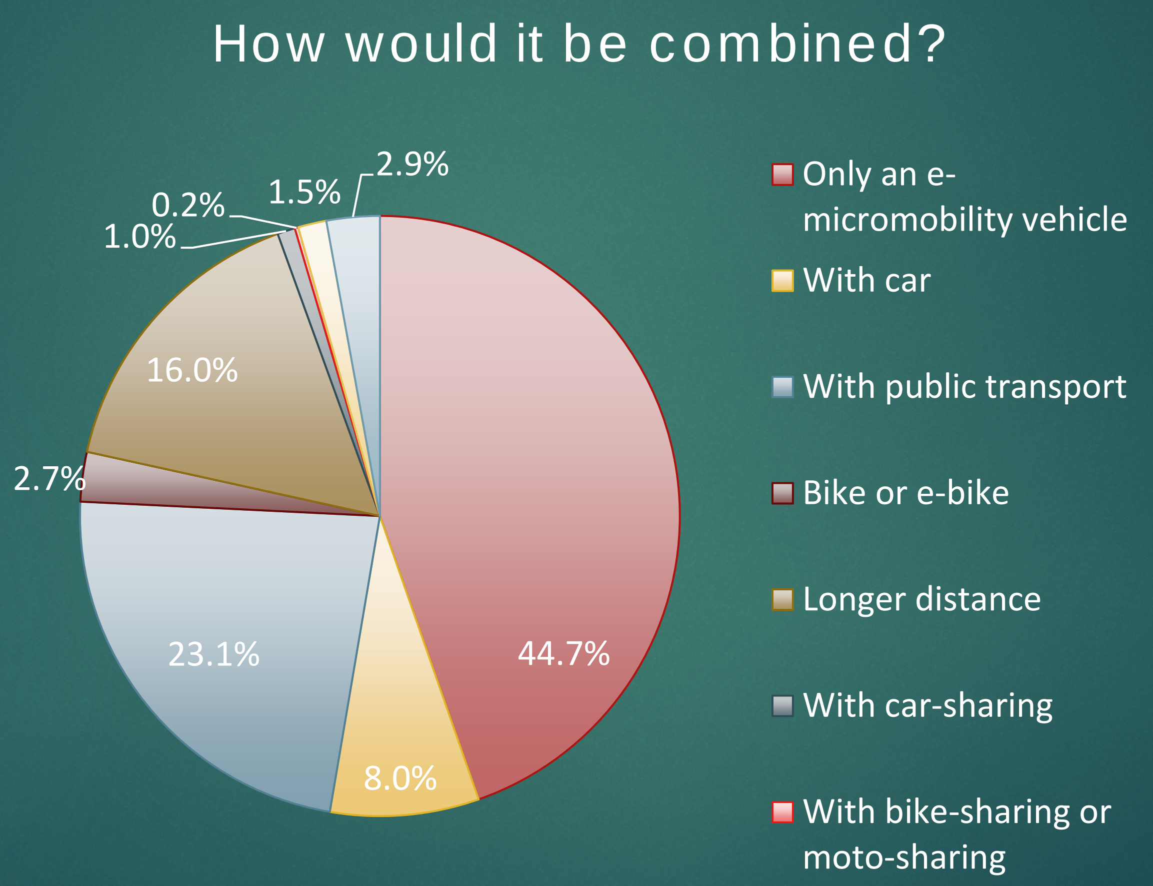


Concerns

Explore e-micromobility travel behaviour

Results

Quantitative survey approach

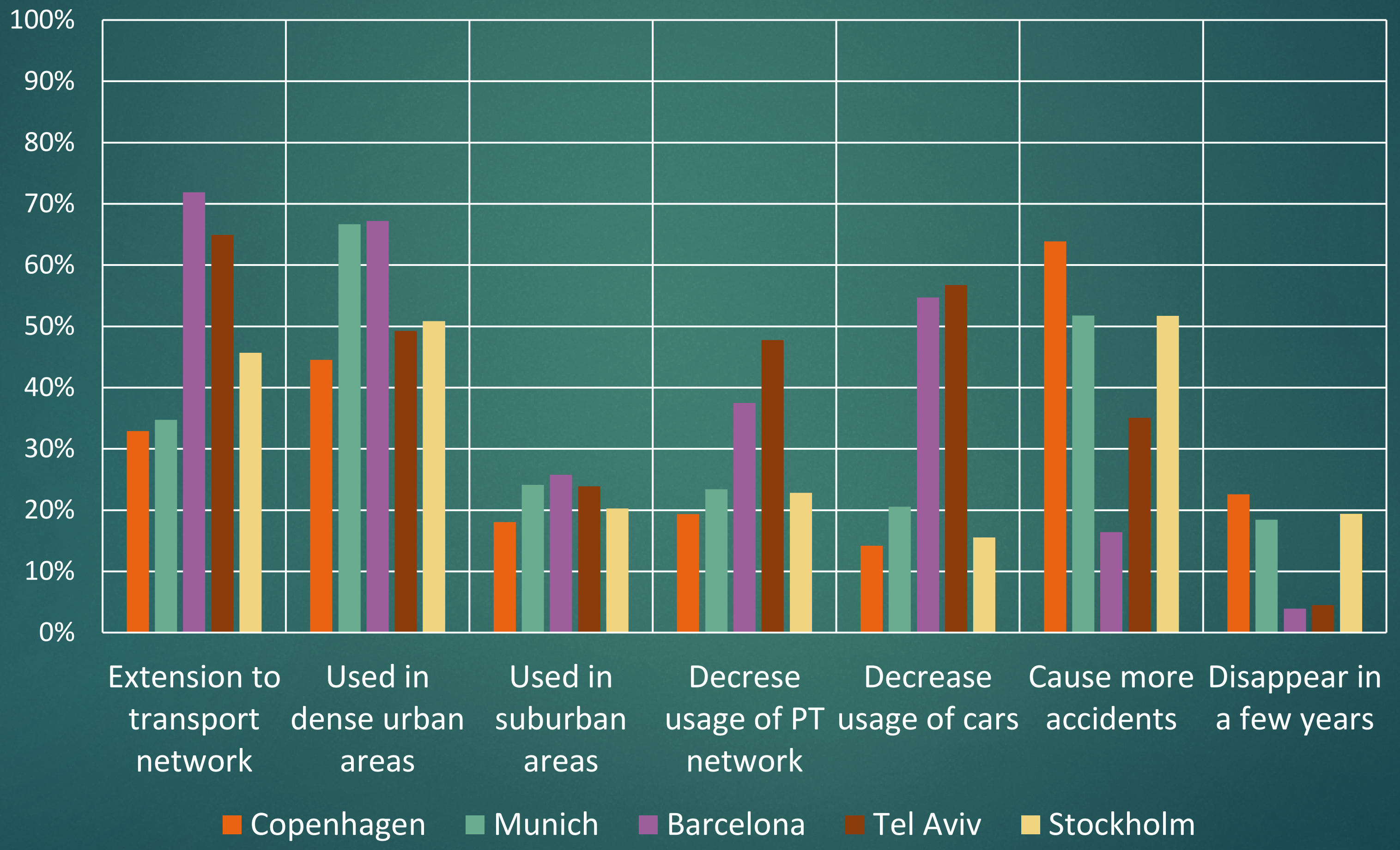


Effects on the city structure and transportation network by location

Explore e-micromobility travel behaviour

Results

Quantitative survey approach



Effects on the city structure and transportation network by location

Explore e-micromobility travel behaviour

Results

SP Estimated parameters

	Copenhagen		Munich		Barcelona		Tel Aviv		Stockholm	
Coefficient	values	t-value	values	t-value	values	t-value	values	t-value	values	t-value
ASC_BIKE	1.78	3.86	2.31	6.13	1.21	4.12	0.77	2.68	0.37	1.07
ASC_CAR	------------------------fixed--------------------------									
ASC_EMIC	1.03	2.03	1.21	2.53	2.25	7.57	1.13	3.80	0.44	1.46
ASC_PT	1.33	2.58	2.32	5.83	2.06	6.40	1.65	5.12	1.26	4.31
γ,bike_inc	0.19	2.40	-0.17	-3.15	0.00	-0.02	0.09	1.94	0.09	1.96
γ,car_inc	------------------------fixed--------------------------									
γ,emic_inc	0.00	0.01	-0.21	-2.72	0.18	2.63	-0.02	-0.41	0.07	1.30
γ,pt_inc	0.19	2.37	-0.14	-2.57	-0.19	2.91	-0.07	-1.41	0.12	2.56
BETA_FARE	-0.01	-0.33	-0.85	-3.89	-0.94	-4.96	-0.19	-3.71	-0.03	-3.18
BETA_TIME	-0.07	-3.21	-0.09	-4.87	-0.09	-4.77	-0.13	-7.01	-0.05	-3.47
Sample Size	656.00		937.00		830.00		828.00		1297.00	
Rho-square:	0.28		0.237		0.121		0.135		0.112	

- Highest ASC in Barcelona
- ASCemic (+) in all models
- Copenhagen lower on e-micromobility a high on Bike
- Munich and Copenhagen high on Bike, the rest high on e-micromobility

- Stockholm and Copenhagen (+) values for all
- Munich (-) values for all
- Tel Aviv (-) for PT and e-micromobility
- Barcelona (-) for PT (+) for e-micromobility

- All negative values = disutility
- Munich and Barcelona had higher disutility
- Lower disutility from Copenhagen and Stockholm

Explore e-micromobility travel behaviour

Results

SP Systematic functions

=> $V_{i,t} = \underline{ASC_i} + \underline{\gamma_{i,k}} S_{k,t} + \sum_m \underline{\beta_{i,m}} X_{i,m}$

Systematic Functions – Results
$V_{i,copenhagen} = ASC_i + \gamma_{i,income} * 5.85 + -0.01 * (X_{i,fare}) + -0.07 * (X_{i,time})$
$V_{i,munich} = ASC_i + \gamma_{i,income} * 5.42 + -0.85 * (X_{i,fare}) + -0.09 * (X_{i,time})$
$V_{i,barcelona} = ASC_i + \gamma_{i,income} * 3.44 + -0.94 * (X_{i,fare}) + -0.09 * (X_{i,time})$
$V_{i,tel\ aviv} = ASC_i + \gamma_{i,income} * 4.88 + -0.19 * (X_{i,fare}) + -0.13 * (X_{i,time})$
$V_{i,stockholm} = ASC_i + \gamma_{i,income} * 5.44 + -0.03 * (X_{i,fare}) + -0.05 * (X_{i,time})$

Income average values

Estimated Beta for fare

Estimated Beta for time

=> $P_i = \frac{e^{V_i}}{\sum_{j=1}^{J} e^{V_j}}$

Explore e-micromobility travel behaviour

Results

SP Estimated Probabilities

Alternatives		Copenhagen	Munich	Barcelona	Tel Aviv	Stockholm
	Mean Income Value	5.85	5.42	3.44	4.88	5.44
Car	fare	22.5	1.5	1.5	5.775	35
	time	12	12	12	12	12
	Vt	-1.065	-2.355	-2.490	-2.657	-1.650
	Probability	3.79%	9.41%	5.71%	13.25%	9.58%
Public Transport	fare	15	1	1	3.85	30
	time	20	20	20	20	20
	Vt	0.892	-1.089	-1.333	-1.682	0.013
	Probability	26.79%	33.36%	18.15%	35.15%	50.57%
E-micromobility	fare	30	2	2	7.7 ④	30
	time	15	15	15	15	15 ③
	Vt	-0.320	-2.979	-0.361	-2.283	-1.650
	Probability	7.97%	5.04%	47.95%	19.26%	9.58%
Bike-sharing	fare	12 ②	0.8	0.8 ①	3.08	8
	time	15	15	15	15	15
	Vt	1.722	-0.642	-0.892	-1.765	-0.500
	Probability	61.45%	52.18%	28.20%	32.33%	30.27%

- ① A higher degree of e-micromobility usage is expected in Barcelona
- ② Munich and Copenhagen are less conducive for the use of e-micromobiles, as bike-sharing was overall preferred.
- ③ **Stockholm** is more conducive for the use of PT, with a low degree of e-micromobility usage
- ④ The second highest probability of e-micromobility was seen in Tel Aviv, as PT and bike-sharing were overall preferred.

Discussion and Conclusions

Overall findings

- E-micromobiles are not a primary mode and is not used regularly in all locationns
- Fees and prices are not satisfactory, especially in Scandinavia
- Better pricing in Scandinavia is needed for better competition (fares are the same as car usage)
- E-micromobiles face high competition in Scandinavia (fundamental relationship with bikes)
- It may reach potential with suitable infrastructure and policies; given that safety, ilegal parking and conflict with other modes are the main concerns
- E-micromobiles to replace walking trips and used along with public transportation, it is proposed to have parking facilities near PT stations
- All locations have low time sensitivity (good for e-micromobiles)
- All locations have high price sensitivity (especially in Munich and Barcelona)
- E-micromobility is shown strong bias in Barcelona and Tel Aviv, while Stockholm, Copenhagen and Munich lack interest (bias)

Questions?